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# Stereotype Threat Impairs Older Adult Driving

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*Summary: Stereotypes can harm human performance, especially when activated in individuals with diminished working memory capacity (WMC). Performance implications for the stereotype of poor driving in older adults were investigated. Using a sample of older adults, WMC (the ability to maintain task goals and ignore distractions) and driving performance [brake reaction time (RT), following distance, and crashes] were assessed, the latter using a high-fidelity simulator. Elderly participants under stereotype threat with reduced WMC exhibited slower brake RTs and longer following distances compared with a control condition that was not threatened. This driving profile was characteristic of cognitive distraction. Stereotype threat has clear consequences for human performance in a common real-world task—driving—that is critical to public safety. Furthermore, these findings suggest caution in how the media and public policy communicate information about older adult driving. Copyright © 2015 John Wiley & Sons, Ltd.*

Stereotypes can have harmful effects on human performance in stereotype-relevant domains when individuals are made aware of negative stereotypes specific to their group (Steele & Aronson, 1995). Stereotype threat is defined as '… being at risk of confirming, as self-characteristic, a negative stereotype about one's own group' (Steele & Aronson, 1995, p. 797). It has been linked to poor performance in a variety of domains, such as race and intelligence (Steele & Aronson, 1995) and gender and math performance (Spencer, Steele, & Quinn, 1999). We investigated performance implications for the stereotype of poor driving ability in older adults (Joanisse, Gagnon, & Voloaca, 2012; Lambert, Seegmiller, Stefanucci, & Watson, 2013). Driving is a safety-critical task. Hence, if older adult driving is vulnerable to stereotype threat, which may be activated by negative media and public policy information about older adult driving performance, public safety may be jeopardized.

Past research using driving simulation and other driving-relevant technologies has demonstrated that driving performance variables are influenced by stereotype threat. Specifically, Yeung and von Hippel (2008) demonstrated that women placed under stereotype threat were twice as likely to hit jay-walking pedestrians in a driving simulator. Skorich et al. (2013) examined novice drivers using a computer-administered driving hazard detection task and found that a subtle stereotype threat manipulation led to improved hazard detection, while a blatant threat manipulation led to reduced hazard detection. Finally, and most relevant to the present paper, Joanisse, Gagnon, and Voloaca (2013) tested stereotype threat effects in older adult drivers using driving simulation. Older adults under stereotype threat committed more driving errors (e.g., speeding, missed stop signs, and crossing the center line) than control participants.

Despite the robust nature of stereotype threat effects, the mechanisms behind these effects are not completely clear, and no single mechanism can completely account for their wide-ranging impacts (Smith, 2004). For example, Joanisse et al. (2013) found that domain identification (i.e., whether or not driving is considered to be important to one's identity) moderated the impact of stereotype threat on older adult driving behavior. This moderator has been observed in other stereotype threat studies with other populations; however, it is only one of several possible stereotype threat mechanisms, and no single mechanism has completely explained the relationship between stereotype threat and performance (Smith, 2004). Working memory capacity (WMC) has also been shown to moderate stereotype threat effects (Schmader & Johns, 2003). Specifically, WMC is operationalized as one's ability to maintain task goals in the face of distraction (Engle, 2002).

Accumulating evidence suggests that stereotype threat may create a source of distraction that disrupts cognitive processing by competing for limited WMC resources (Schmader & Johns, 2003), thereby interfering with activity in the prefrontal cortex that might otherwise be used to support task goals (Krendl, Richeson, Kelley, & Heatherton, 2008). Specifically, according to this perspective, stereotype threat consumes limited WMC resources by activating three separate but related processes that tap WMC resources: a physiological stress response, a tendency to actively monitor performance, and negative thoughts and emotions. This perspective, referred to as the integrated processes model of stereotype threat (Schmader, Johns, & Forbes, 2008), suggests that populations with deficits in prefrontal cortex, including some older adults, may have increased susceptibility to stereotype threat effects for tasks that impose a high cognitive demand on WMC. However, this hypothesis was challenged by research on 'choking under pressure'. Studies on choking under pressure have shown that strong evaluative scrutiny can selectively interfere with the performance of individuals with high WMC, presumably because performance pressure consumes the executive control resources that an individual with high WMC typically uses to attain

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superior performance (Beilock & Carr, 2005; Beilock & DeCaro, 2007; Gimmig, Huguet, Caverni, & Cury, 2006).

Régner et al. (2010) designed a study to resolve these contrasting predictions by manipulating performance pressure alone versus performance pressure with stereotype threat in male and female college students who strongly identified with engineering. They found that women with low WMC underperformed on a test of logical reasoning ability compared with men with low WMC in the combined condition (i.e., when stereotype threat was present with performance pressure). In the performance pressure only condition, women low in WMC outperformed those in the combined condition. For individuals high in WMC, individuals performed equally under both conditions. More recently, Hutchison, Smith, and Ferris (2013) demonstrated this same directionality of WMC moderation of stereotype threat effects using male participants. Thus, while historically there have been contrasting predictions regarding the directionality of stereotype threat moderation, recent research strongly suggests that when stereotype threat is manipulated, it selectively impact those with low WMC.

Working memory capacity is a particularly interesting moderator with regard to its relationship with cognitive aging (Strayer, Watson, & Drews, 2011; West, 1996). Attentional resources, including WMC, are thought to be crucial for safe driving (Strayer & Drews, 2007; Watson & Strayer, 2010). Impaired driving is well documented in populations with suspected prefrontal deficits, such as those diagnosed with attention deficit disorder (Barkley & Cox, 2007). Furthermore, dividing young adults' attention via a cell phone conversation slows brake reaction times (RTs) and induces more missed stops to traffic signals (Strayer & Johnston, 2001). Watson, Lambert, Cooper, Boyle, and Strayer (2013) demonstrated that individuals with lower WMC had a greater following distance behind a lead vehicle and took longer to press their brake pedal after that lead vehicle had applied its brakes—a pattern characteristic of cognitive impairment and distracted driving (Strayer et al., 2011). Further, Lambert et al. (2013) found that young adults with higher WMC were better able to control implicit associations between advanced age and dangerous driving than young adults with lower WMC. This work suggests that negative stereotypes of older adult drivers are amenable to control and that the controllability of the stereotype depends on individual differences in WMC. It is an open question, however, whether this high/low WMC group difference will generalize to a stereotype threat paradigm by moderating the impact of stereotype activation on older adults' actual or simulated driving performance.

The present study measured the impact of stereotype threat and the possible moderating role of WMC on older adult drivers. Consistent with the integrated processing model of stereotype threat (Schmader et al., 2008) and the findings of Régner et al. (2010), we predicted that stereotype threat would introduce a source of interference that would require WMC resources to regulate. We hypothesized that stereotype threat would selectively impair older adult drivers with reduced WMC because they would be less equipped to regulate this distraction than older adults with higher WMC. To test this idea, we employed a car-following paradigm in a high-fidelity driving simulator. Two continuous driving performance measures, brake RT and following distance, were selected because both have been shown to be related to WMC and sensitive to the effects of cognitive distraction (Strayer et al., 2011; Strayer & Johnston, 2001; Watson et al., 2013). We used a two-group, between-participants design to assess stereotype threat—threat and control—in which the stereotype threat manipulation was the only procedural difference between the threat and control groups. We hypothesized that, relative to controls, older adult drivers placed under stereotype threat would have slower brake RTs and longer following distances and that this pattern would be most prominent in older adults with less WMC. In addition, we recorded crashes because distracted driving has been show to increase the likelihood of crashes (Redelmeier & Tibshirani, 1997).

## METHOD

### Participants and materials

Sixty licensed, older adult drivers, with normal or corrected-to-normal vision, were recruited from the Salt Lake City community. Participants were initially contacted if they had previously indicated interest in participating in psychological research by visiting a lab-staffed booth at a local senior fair and providing their names and phone numbers. All volunteers came to the Cognitive Science Lab on the University of Utah campus where informed consent was obtained, and each was paid $30.00 for their participation. Of these 60 participants, data from 39 were retained in the sample for analysis. Reasons for exclusion included motion sickness, a common problem for older adults in driving simulation research (Brooks et al., 2010); inability to adhere to the following distance instructions in the practice drive; difficulties reaching the gas and brake pedals; participant request for data removal; and procedural error. While this attrition rate of 35% is relatively high, it is comparable with other studies using driving simulation with older adult participants (Joanisse et al., 2013; Mullen, Weaver, Riendeau, Morrison, & Bédard, 2010). Participants retained in the final sample ranged in age from 62 to 83 years (mean age = 72.54). Twenty participants were male and 19 were female.

The study utilized a PatrolSim, high-fidelity driving simulator manufactured by L3Communications/I-SIM, which recreated realistic driving environments through vehicle-dynamics, traffic-scenarios, and road-surface software. An operation span task (OSPAN) measured individual differences in WMC by asking participants to memorize words while concurrently solving math problems (Turner & Engle, 1989). Math/word pairs were presented in set sizes ranging from two to five pairs per set. For each math/word pair, participants solved an equation and tried to memorize the word. At the end of each set of stimuli, they were asked to recall words in the correct serial order. One point was counted for each word recalled in the correct serial position with a maximum score of 42 points. All participants met a minimum math accuracy criterion of 80%.

### Procedure

Participants completed two sessions, 1–14 days apart. In Session 1, visual acuity and color blindness were assessed, stereotype threat was manipulated, and driving performance was measured. Because tests that assess memory have been shown to induce stereotype threat and impact performance in older adults (Rahhal, Hasher, & Colcombe, 2001), WMC was assessed using the OSPAN task during Session 2. Further, testing memory at a later date should have also reduced the likelihood that the stereotype threat manipulation from Session 1 would have impacted participants' WMC scores obtained in Session 2. Consistent with this argument, an independent samples *t*-test indicated that mean WMC between participants who were randomly assigned to the stereotype threat and the control condition did not significantly differ $t(37) = 0.27$, $p = .80$.

We chose to use a two-group, between-participants design—threat versus control—similar to the Aronson et al. (1999) classic study in which the stereotype threat manipulation was the only procedural difference between the threat and control groups. This design decision was also guided by recent research in stereotype threat and driving (Joanisse et al., 2013; Skorich et al., 2013) and the literature on driving performance and cognitive distraction in which a control group is often directly compared with an experimental group (Strayer et al., 2011; Strayer & Drews, 2007; Strayer & Johnston, 2001; Strayer & Drews, 2004). As such, all participants were given extensive verbal and written instructions including (i) institutional review board literature on the purpose of the study, (ii) instructions to follow the rules of the road, and (iii) a lengthy practice sequence to facilitate compliance with these instructions. Further, all participants were told that the purpose of the experiment was to investigate relationships between thinking and concentration, driving performance, and social issues. Next, participants were familiarized with the components of the driving simulator using a practice sequence during which they were instructed to follow the rules of the road by obeying posted speed limits and staying in their lane. The practice sequence involved simulated driving in residential and highway environments and took approximately 5 minutes to complete. They were then trained to follow a lead vehicle at a 2-second-to-crash following distance, braking whenever the lead vehicle's brake lights appeared so as to avoid a rear-end crash. If they fell too far behind the lead vehicle, a horn sounded to remind them to reduce their following distance. Participants were told to use the practice sequence as a guide for appropriate following distance in subsequent drives (when the horn would no longer sound). In this way, the car-following paradigm taxed limited WMC resources, requiring participants to maintain the task goal associated with the prescribed following distance by controlling the speed of their vehicle to match the lead car, which included periodically pressing their brake pedal.

Next, participants were randomly assigned to the stereotype threat or control condition. In the stereotype threat condition, participants heard the following script:

> Before we begin collecting driving data, I want to tell you a little more about the purpose of this study. Older adults, as a group, are stereotyped to be bad drivers. While it may be the case that not all older adults are bad drivers, there is some evidence that this stereotype may be true. Here are some examples of evidence that older adults may be bad drivers.

These participants were then given materials containing news reports on elderly drivers in traffic accidents and a graph of national statistics on fatal crashes. The experimenter explained the figure by noting that, 'As people get older, it is more likely that they will be involved in a fatal accident. In some cases, this probability is greater than that of novice teenage drivers'. Finally, the experimenter stated,

> One purpose of this study is to test whether or not this stereotype is valid. To do so, we will be recording data on your driving performance in the next drive.

Like Aronson et al., we included both the rationale for the experiment and the news clippings and figure in order to (i) make the participants feel targeted by a stereotype and (ii) give some plausibility to the stereotype. Participants in the control condition were also told that driving performance data would be collected during the next drive. All participants were then read instructions for safe and lawful driving during the experimental drive and data collection commenced.

During the experimental drive, all participants drove approximately 15 minutes in the center lane of a three-lane highway, following a lead car programmed to drive ahead of them in the same lane and brake periodically. Other vehicles were programmed to drive in the adjacent left and right lanes. Participants were instructed to follow the lead vehicle, braking whenever this lead vehicle braked, and to exit at the city of Murray, which required a lane change. Upon completion, participants were told the study investigated the effects of stereotype threat. They then departed, returning to the lab for Session 2 at a later date. Participants were debriefed at the conclusion of the study.

## RESULTS

We first examined variable distributions. Both dependent measures were strongly positively skewed, but transformations to normalize data did not change the results. SPSS boxplots were used to check the data for extreme outliers. None were identified $[QI - (3 \times IQR)]$ or $[Q3 + (3 \times IQR)]$.[1]

We then examined brake RT to determine whether stereotype threat produced slower response times for older adults with reduced WMC, a finding that would be consistent with distracted driving (Strayer & Drews, 2004, 2007). To address this possibility, mean brake RTs were computed for each participant. Using three successive models, hierarchical linear regression was then used to examine and compare the unique and multiplicative potential effects of stereotype

[1] While no extreme outliers were identified $[QI - (3 \times IQR)]$ or $[Q3 + (3 \times IQR)]$, mild outliers were noted $[QI - (1.5 \times IQR)]$ or $[Q3 + (1.5 \times IQR)]$. To address the potential influence of these mild outliers, the data were also analyzed using robust regression, which is less sensitive to non-normal data, unequal variance, and the influence of outliers (Rousseeuw & Leroy, 1987). Results with robust regression were comparable with those of ordinary least squares regression.

threat and WMC on brake RT. Because age and WMC can co-vary, age was entered in Step 1, stereotype threat and WMC were entered simultaneously in Step 2, and an interaction term for stereotype threat and WMC was entered in Step 3. Step 1 resulted in a non-significant model [$F(1, 37) = 0.16$, $p = .69$, $R^2 = -.02$], with a non-significant main effect of age ($\beta = -.07$, $p = .69$). Step 2 resulted in a significant model [$F(3, 35) = 4.54$, $p < .01$, $R^2 = .28$], with significant main effects of WMC ($\beta = -.39$, $p < .02$) and stereotype threat ($\beta = .37$, $p < .02$). Step 3 resulted in a significant model [$F(4, 34) = 6.11$, $p = .001$, $R^2 = .35$], with an interaction between stereotype threat and WMC ($\beta = -1.81$, $p < .01$) qualifying the lower order main effects.

Bivariate Pearson product–moment correlations between WMC and brake RT were calculated separately for control and stereotype threat conditions in order to determine the nature of this interaction. There was no relationship between WMC and brake RT in the control condition [$r(17) = .11$, $p = .64$]. However, the relationship between WMC and brake RT in the stereotype threat condition was significant and negative in direction [$r(18) = -.62$, $p < .01$]. Because the main effects of WMC and stereotype threat and, more importantly, the interaction between these two variables were statistically significant above and beyond any variance that could be explained by a simple age-related decline in driving, we can be confident that the interaction was due to individual differences in WMC. As predicted and depicted in the top panels of Figure 1, stereotype threat increased brake RT but only for older adults with lower WMC. Brake RT of participants with lower WMC was approximately double that of those with higher WMC (left panel). Furthermore, no such relationship was observed between WMC and brake RT without stereotype threat (right panel).

Next, we examined following distance to determine whether stereotype threat elongated the following distance of older adults with reduced WMC, a pattern that would be consistent with distracted driving (Strayer & Drews, 2007). Hierarchical linear regression was again used to examine the potential effects of stereotype threat and WMC on driving performance. Age was entered in Step 1, stereotype threat and WMC were entered simultaneously in Step 2, and an interaction term for stereotype threat and WMC was entered in Step 3. Step 1 again resulted in a non-significant model [$F(1, 37) = 0.01$, $p = .93$, $R^2 = -.03$], with a non-significant main effect of age ($\beta = .02$, $p = .93$). Step 2 resulted in a significant model [$F(3, 35) = 2.97$, $p < .05$, $R^2 = .13$], with a marginally significant main effect of WMC ($\beta = -.04$, $p = .051$) and a significant main effect of stereotype threat ($\beta = .34$, $p < .04$) . Step 3 resulted in a significant model [$F(4, 34) = 4.12$, $p < .01$, $R^2 = .25$], where an interaction between stereotype threat and WMC ($\beta = -1.73$, $p < .02$) qualified the lower order main effects.

Bivariate Pearson product–moment correlations between WMC and following distance were calculated separately for control and stereotype threat conditions in order to determine the nature of this interaction. There was no relationship between WMC and following distance in the control condition [$r(17) = .21$, $p = .39$]. However, the

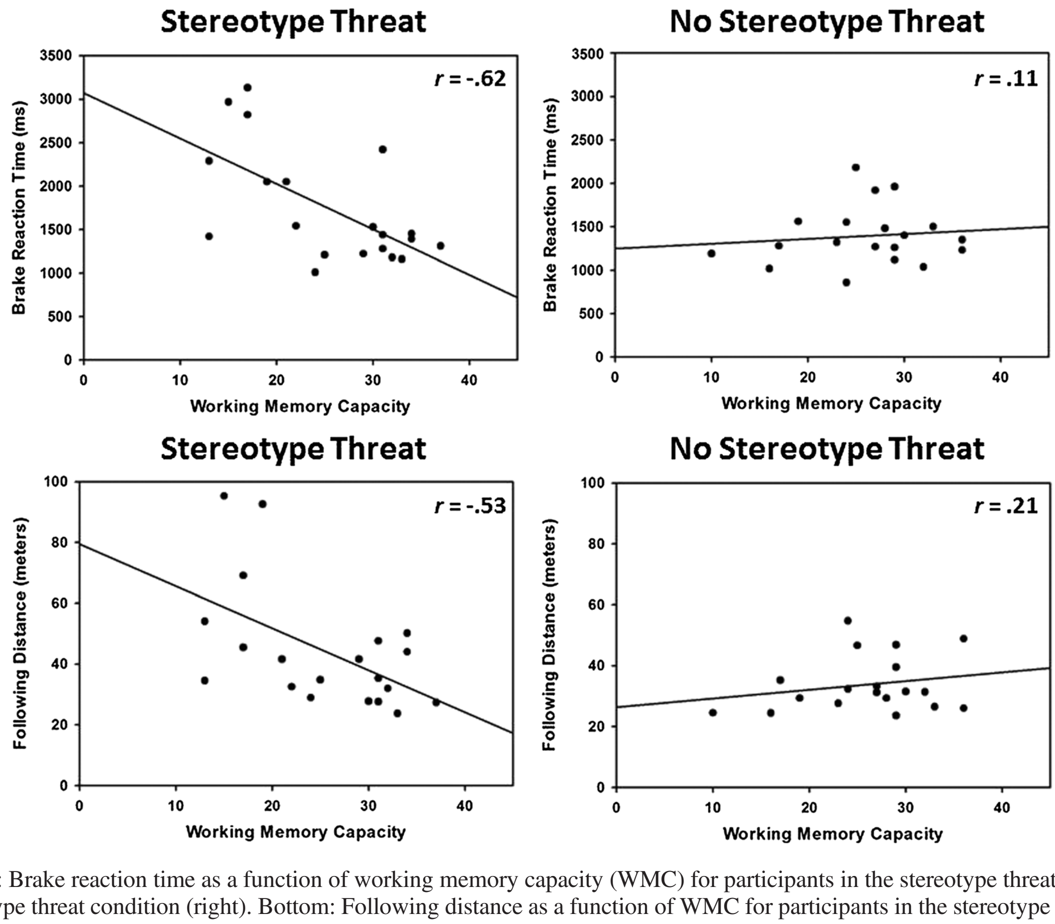


Figure 1. Top: Brake reaction time as a function of working memory capacity (WMC) for participants in the stereotype threat condition (left) and no stereotype threat condition (right). Bottom: Following distance as a function of WMC for participants in the stereotype threat condition (left) and no stereotype threat condition (right)

 

relationship between WMC and following distance in the stereotype threat condition was significant and negative in direction [$r(18) = -.53$, $p < .02$]. As was the case with brake reaction time, the main effects of WMC and stereotype threat, and more importantly, the interaction between these two variables, on following distance were statistically significant above and beyond the variance explained by age-related decline in driving. Thus, again, we can be confident that the interaction was due to individual differences in WMC. As predicted and depicted in the bottom panels of Figure 1, stereotype threat increased following distance but only for older adults with lower WMC. Again, following distance of participants with lower WMC was approximately double that of those with higher WMC (left panel). And again, no such relationship was observed between WMC and following distance without stereotype threat (right panel).

Crash data were first examined using hierarchical binary logistic regression to assess the possible role of WMC in crash likelihood. WMC was treated continuously, and stereotype threat conditions were treated dichotomously. Age was entered in Step 1, WMC and stereotype threat were entered in Step 2, and the interaction of these variables was entered in Step 3. No main effects were significant [Age (Wald = 0.01, $p = .94$); WMC (Wald = .36, $p = .55$); stereotype threat], nor was the interaction between WMC and stereotype threat (Wald = 0.92, $p = .34$). Our ability to observe these effects in crashes may have been limited by the properties of this dependent measure, a single binary observation.

To examine crash data irrespective of WMC, an odds ratio (OR) was calculated to quantify crash likelihood for the stereotype threat manipulation. Traditional methods for determining significance of ORs (Fisher's exact test) have been shown to be too conservative for small samples like ours (see Agresti, 2002, for details). Thus, statistical significance ($OR > 1$) was calculated using Barnard's unconditional method (Barnard, 1945). This test of significance calculates the probability of getting the given combination or a more extreme combination out of all possible combinations, and it then uses the chi-square distribution to determine significance. Five crashes occurred in the stereotype threat condition and one in the control condition. Five of the six crashes occurred while attempting to change lanes to exit the highway and end the scenario. The risk of crash was six times greater for those older adults in the stereotype threat condition than those in the control condition. Nonetheless, our test was under-powered, producing a marginally significant $p$-value ($OR = 6.00$, $p = .06$). However, given the large effect size and its potential implications for traffic safety, we believe these results to be noteworthy.

## DISCUSSION

As predicted, under stereotype threat, older adult drivers lower in WMC had slower brake reaction times and longer following distances. This profile is well associated with cognitive distraction in the attention and driving literature (Strayer et al., 2011). Moreover, the interaction of WMC and stereotype threat on brake RT and following distance strongly supports an integrated process model of stereotype threat (Schmader et al., 2008) where individuals with reduced WMC, such as some older adults, are most likely to be affected by stereotype threat. Thus, it appears that, in addition to domain identification (Joanisse et al., 2013), WMC is an important factor in predicting which older adults will be most vulnerable to the deleterious effects of stereotype threat on driving performance. To our knowledge, only three other studies have investigated the influence of stereotype threat on driving performance (Skorich et al., 2013; Yeung & von Hippel, 2008; Joanisse et al., 2013), and none have specifically targeted the WMC related driving performance indices of brake RT and following distance in older adult drivers. The results of the present study corroborate those of Joanisse et al. (2013), indicating that an important and increasingly large segment of society (Department of Health and Human Services: Administration on Aging, 2010), older adults, may be stigmatized by stereotypes of poor driving ability and vulnerable to stereotype threat.

One might wonder whether slowing in brake RT and increased following distance under conditions of stereotype threat should be interpreted as cautious rather than distracted driving. Given slowed brake RTs, it would be prudent to adjust one's following distance to allow more time for braking execution. However, if this were the case, one would expect that those higher in WMC would be better able to adopt and adhere to this safer driving strategy than those lower in WMC, that is, higher WMC is linked to better goal maintenance (Braver & West, 2008; Kane & Engle, 2003). This is inconsistent with the present results where those lowest in WMC produced slower brake RTs and increased following distances. Further, this driving pattern has been linked to aging and WMC (Watson et al., 2013) and typifies distracted driving (Strayer & Drews, 2004). When conversing on a cellular phone, a context in which the pattern is clearly linked to impaired driving performance, drivers also show slower brake RTs and greater following distances (Strayer & Drews, 2004). Thus, it seems unlikely that stereotype threat motivated participants to drive more safely, especially given the greater likelihood of crashes. Rather, stereotype threat appears to be a distraction and to selectively diminish the driving performance of older adults lowest in WMC.

Overall, the data reveal a cognitively demanding driving task did not show a relationship with WMC without threat, perhaps owing to limited sample size and the fact that older adults tend to have greater expertise in driving. However, this expertise was overwhelmed by the presence of a brief threat manipulation, thereby unmasking relations between individual differences in WMC and driving performance. Because we used a two-group stereotype threat design in which the stereotype threat manipulation was the only procedural difference between the threat and control groups and both groups engaged in a cognitively demanding task (driving), we can conclude that any effect of our stereotype threat manipulation would have carried over to driving performance above and beyond whatever capacity was already being consumed by the control condition.

Consistent with the integrated process model of stereotype threat (Schmader et al., 2008), the threat manipulation may have encouraged recursive self-monitoring of negative thoughts and emotions, and evaluation of one's performance to produce a pattern of driver distraction only in our experimental group only that selectively affected the driving performance of individuals who did not have sufficient WMC to successfully divide attention between the driving task and threat management. Importantly, this two-group design follows the same control procedures used in the literature on driving performance that is often directly compared with an experimental group, especially as it relates to public safety issues of cognitive distraction (e.g., where the experimental group might involve concurrent use of a cell phone while driving or even texting while driving in place of stereotype threat).

Driving is commonplace in Western culture, and quality of driving performance can potentially affect anyone on the road. Thus, our findings present an urgent safety concern. Although federal legislation concerning advanced age and driving eligibility does not currently exist, state-based efforts toward this end are ongoing. For example, in the state of Florida, which has the largest older adult population according to the US Census Bureau (2012), the Florida Department of Highway Safety and Motor Vehicles created the Florida Grand Driver Program®. This program allows concerned family members, medical doctors, or law enforcers to report senior drivers who they believe to be safety risks. The program has the authority to require drivers to take a written and/or road driving test with the possibility that they may lose their license to drive (Florida Department of Highway Safety and Motor Vehicles, 2011). Ironically, the re-evaluation process and even the media coverage of these policies may unintentionally elicit stereotype threat effects in driving, akin to those reported here, ultimately jeopardizing public safety. If so, it is possible that public policy initiatives like the Florida Grand Driver Program® may actually enhance the very problems with driver distraction in the elderly that they were enacted to help avoid, particularly for older adults with reduced WMC.

Future research toward an improved understanding of social factors that activate stereotypes and underlying cognitive mechanisms like WMC that regulate stereotype threat is necessary. Examining more subtle stereotype threat manipulations, their relationship with WMC, and their impact on older adult driving performance would be a particularly interesting direction for future research. It is possible that subtle stereotype threat manipulations, in contrast to the blatant manipulation used in the present study, could have a protective effect. The Skorich et al. (2013) study found that a blatant stereotype threat manipulation reduced novice drivers' hazard detection performance but that a subtle manipulation actually improved hazard detection performance. A better understanding of the environmental factors that activate stereotype threat and when these factors hamper performance will be critical in the development of effective interventions that improve driver safety on our roadways.

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